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Indian Standard

CODE OF PRACTICE FOR SELECTION, SPLICING, INSTALLATION AND PROVIDING PROTECTION TO THE OPEN ENDS OF CABLES USED FOR CONNECTING RESISTANCE TYPE MEASURING DEVICES IN CONCRETE AND MASONRY DAMS

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CODE OF PRACTICE FOR SELECTION, SPLICING, INSTALLATION AND PROVIDING PROTECTION TO THE OPEN ENDS OF CABLES USED FOR CONNECTING RESISTANCE TYPE MEASURING DEVICES IN CONCRETE AND MASONRY DAMS

Hydraulic Structures Instrumentation Sectional Committee, BDC 60

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CODE OF PRACTICE FOR SELECTION, SPLICING, INSTALLATION AND PROVIDING PROTECTION TO THE OPEN ENDS OF CABLES USED FOR CONNECTING RESISTANCE TYPE MEASURING DEVICES IN CONCRETE AND MASONRY DAMS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 October 1982, after the draft finalized by the Hydraulic Structures Instrumentation Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Rubber insulated and rubber sheathed 3-conductor and 4-conductor stranded flexible cords are used for connecting highly accurate measuring instruments embedded in concrete and masonry dams to suitable terminal boards located in the galleries of the dam.

0.3 A large portion of the cord is embedded in the concrete or mortar in the dam and hence rugged construction, positive imperviousness to moisture at higher pressure, uniform conductor resistance and long life are of paramount importance. The usually severe conditions to which this cord is subjected include ambient air and concrete temperatures of 50°C or so, excessively damp locations, alkaline reaction of concrete and rough treatment during installation.

0.4 In the field, in order to add additional length of cable to that already attached to the instrument for joining it to the terminal boards located in the gallery, it is necessary to splice the cable ends in the field laboratory prior to the embedment of the instruments in the structure.

0.5 Where the ends of cables attached to the instrument are left loose or uncovered for a while until these are properly terminated, a good care for prevention of moisture or water from entering the instrument through the cable ends, is considered necessary.

0.6 It is not practical to vulcanize natural rubber with synthetic rubber. It is, therefore, necessary that the cable to be used should be of the same specification as that attached to the instrument.

0.7 In the case of masonry dams, it is considered necessary to take horizontal and vertical runs of cable through conduits.

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1. SCOPE

1.1 This standard covers the details of specifications of cables, method of splicing and installation of cables, mode of delivery, inspection and test to be carried out on the material used in the manufacture of cables as also on finished cable, pre-embedment tests, cable end protection and fixing the size of conduits.

2. CABLE SPECIFICATIONS

2.1 Type, Size and Ratings — The cord shall consist of three or four cores of tinned annealed high conductivity copper wire with a nominal area of each conductor of 1·5 sq mm insulated with moisture and heat resisting elastomer or PVC insulation and jacketed with elastomer or PVC sheathing. Elastomer insulated cord shall comply with IS : 9968 (Part I)-1981* and PVC insulated cord shall comply with IS : 694-1977†.

2.2 Method of Delivery — The cord shall be in lengths of 300 to 1 000 m with inner and outer ends of each length extending at least one metre outside the reel to facilitate sampling for test purposes.

2.3 Inspection and Tests — Proper inspection and testing shall be carried out with à view to examining the cables in accordance with the provisions contained in IS : 9968 (Part I)-1981* or IS : 694-1977†, whichever is applicable.

3. CABLE SPLICING PROCEDURE

3.1 The instruments for embedment in concrete or masonry dams are often supplied with one metre of multi-core cable attached initially, so that the work of cable splicing shall be done where cable extension is required. Faulty splices are generally a potential source of trouble.

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*Specification for elastomer-insulated cables : Part I For working voltages up to and including 1 100 volts.

†Specification for PVC insulated cables for working voltages up to and including 1 100 volts (*second revision*).

3.2 There are three methods for cable splicing for cable extension to the terminal boxes, namely:

a) Vulcanized rubber splice,

b) Rubber sleeve covering, and

c) Self-bonding tape.

3.2.1 *Vulcanized Rubber Splice* — The following steps shall be followed in the procedure for vulcanizing cable splices:

a) The cable sheath for 80 mm from the cable end shall be removed and joint made of the individual pair of conductors staggered by 25 mm lengths (Fig. 1A) so that the finished splices do not lap;

b) Ten millimetres of rubber insulations from each conductor shall be cut, while taking care not to damage the conductor;

c) The individual conductors shall be twisted and conductors of the same colours put into a copper sleeve and then soldered (Fig. 1B and 1C);

d) The surface of copper sleeve and insulation shall be wiped by using benzene absorbed clean cloth and unvulcanized repair tape wound on it (Fig. 1D);

e) On completion of conductor splicing, the ends of insulations are marked on the cable and unvulcanized tape tightly wound along the whole jointing portion. In this case, in order to obtain a strong adhesion, the surface of sheath, on which unvulcanized tough rubber tape is to be wound shall be roughened for length of about 40 mm by use of file or knife, and polychloroprene rubber paste shall be applied (Fig. 1E);

f) After drying, the splice shall be wrapped with unvulcanized tough rubber tape, carrying the tape up onto the sheath, at least two layers half-lapped (*see* Fig. 1F);

g) Wrapping on the splice shall be completed with vulcanizing tough rubber tape, and all projections shall be cut off with a knife just before completion of the final layer;

h) Continue until the splice is built up to the size of the mould of the vulcanizer;

j) Silicone oil or soapwater shall be applied on the inside surface of metal mould of the vulcanizer. The vulcanizer shall be connected and energized according to the manufacturers' instructions;

k) After the indication of the vulcanizer has reached 100°C (preheating point), vulcanizer shall be opened and the splice put in the metal mould;

m) While energizing, the mould shall be gradually tightened until it is uniformly fastened; and

n) The temperature shall be raised to 140-160°C and kept at that level for about 30 min. Then energizing shall be stopped and after the temperature comes down to about 120°C, the metal mould shall be opened and the splice shall be taken out and excess rubber trimmed off.

3.2.2 *Rubber Sleeve Covering* — The following steps shall be followed:

a) Cable shall be removed and cable ends shall be joined in accordance with the procedure indicated in **3.2.1**(a), through **3.2.1**(c). Insulating sleeves shall be provided over copper sleeves (Fig. 2A and 2B);

b) The jointed conductors shall be enclosed in a rubber sleeve or plastic pipe having open gap, by passing the conductors through the open gap. The rubber sleeve shall be wound on two grooves fixed one on each side of the splice (Fig. 2C). Voids between the rubber sleeve and jointed conductors shall be filled with cable compound;

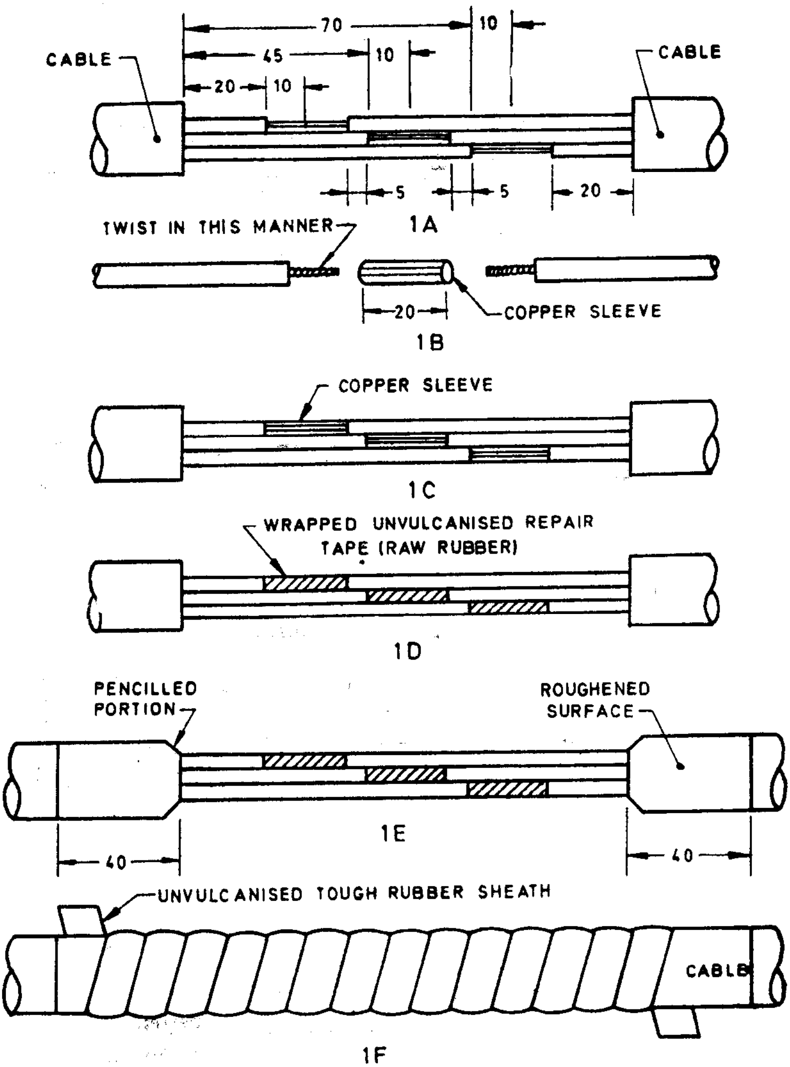
c) Finally, the splicing portion shall be wound with adhesive vinyl-chloride tape (Fig. 2D).

3.2.3 *Self-Bonding Tape* — The self-bonding tape is made from synthetic resin and rubber, which is a good electric insulator and is particularly durable against watering and aging. The following steps shall be followed:

a) Sheath of the cable attached to the instrument shall be removed and conductors spliced in accordance with the procedure given in **3.2.1**(a); and

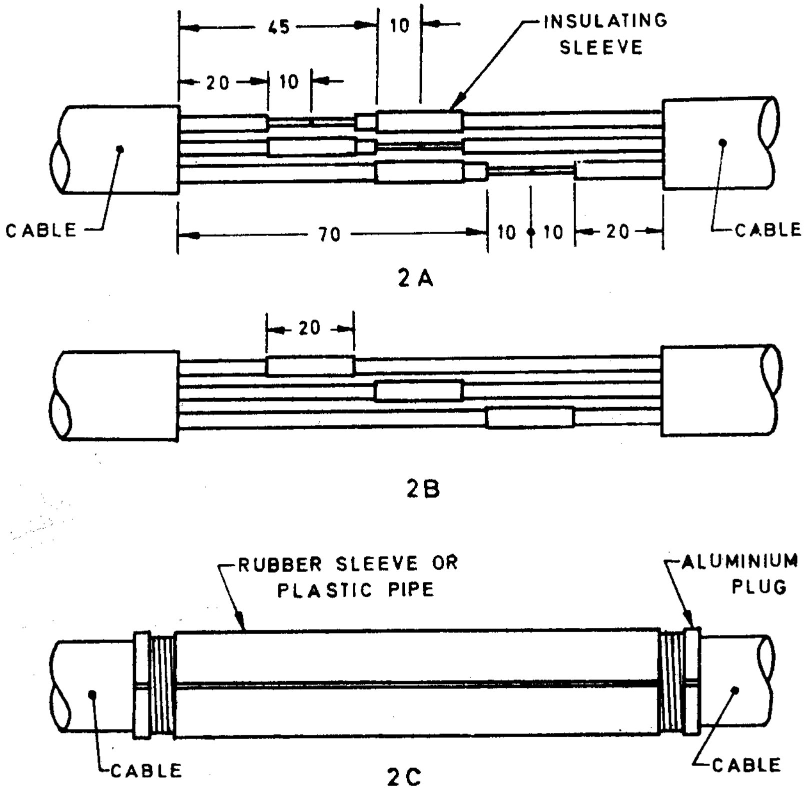
b) Cover with self-bonding tape. After jointing the conductors each of the conductors shall be wrapped with the tape extending it 30 to 40 mm on each side of the splice of individual conductors. In order to obtain a strong adhesion, the surface of the sheath on which self-bonding tape is to be wound shall be roughened for a length of about 30 mm by the use of pumice, file or knife.

The conductors shall then be assembled in a bench and wrapped with the tape extending to make a smooth rounded cross-section.

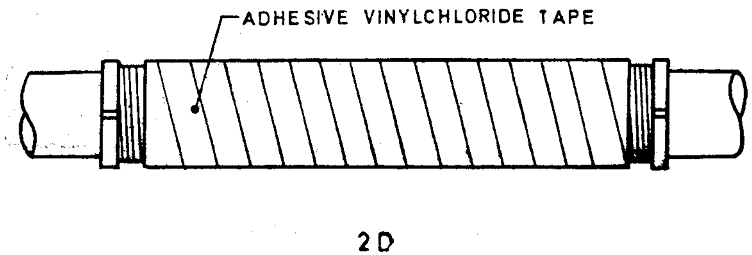


All dimensions in millimetres.

FIG. 1 VULCANIZED RUBBER SPLICE



NOTE — Ends of rubber sleeve shall be tied with wire before pouring cable compound through each gap.



All dimensions in millimetres.

FIG. 2 RUBBER SLEEVE COVERING

4. CABLES AND CONDUITS

4.1 In estimating the length of the cable to be added, a suitable route between the point of embedment of the instrument and the terminal station in the gallery shall be selected by a study of the drawing. In selecting the route, due consideration shall be given to the construction procedures involved in placing the concrete where the instrument is to be embedded and to possible obstructions along the chosen route. After the selected route has been verified, the length of cable required shall be estimated, and a small amount, usually 10% or 1·5 m, whichever is larger, shall be added to allow for extra length required due to normal variation from the selected route. Length of cable should be limited to 75 m as far as possible.

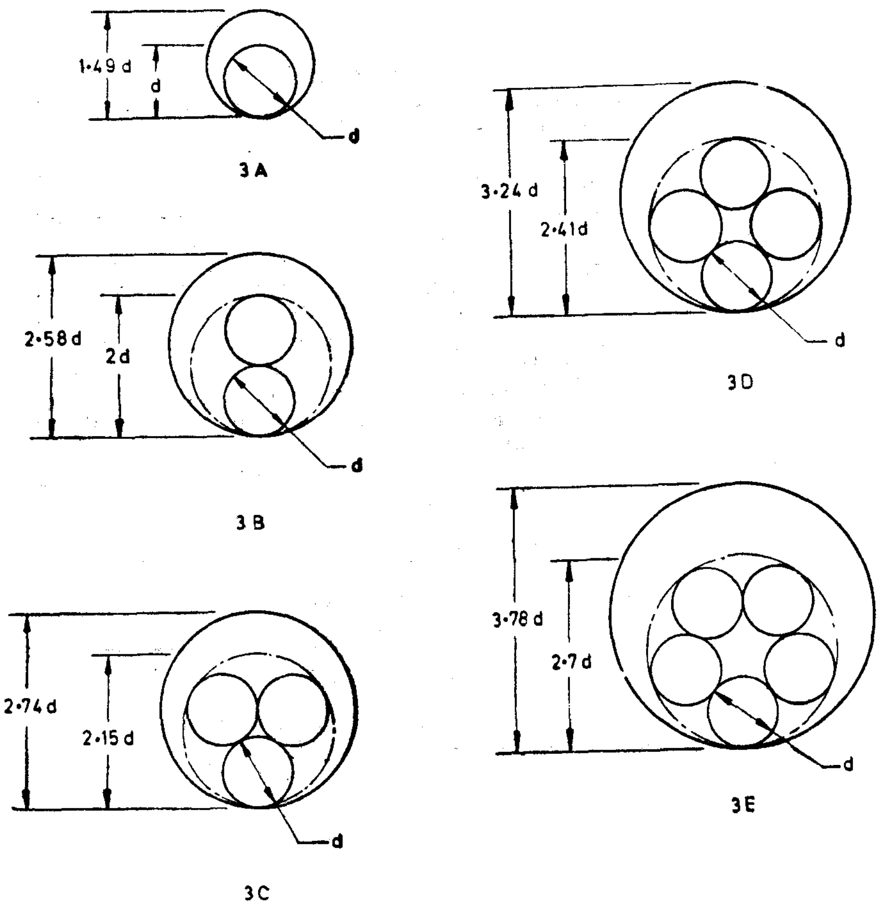
4.2 In general, cables run within conduits in masonry and concrete, both in horizontal and vertical directions. Separate conduit should be used for each individual lift. The conduit may be of any material which will not collapse in fresh concrete, such as galvanized iron, or rigid PVC. The size of the conduit may be chosen by drawing circles to represent the diameter of the cables. In order to allow for pulling friction, provide for one and a half times the number of cables where the conduit is of short length and up to twice the number of circles, as there are cables where the runs are long or there are many bends. Circumscribe these circles with a larger one to find the inside diameter of the conduit.

4.2.1 The size of the conduits may also be chosen according to Table 1.

TABLE 1 CONDUIT CAPACITIES

No. of Cables to be Drawn	Minimum Internal Dia of the Conduit Required	Maximum Internal Cross-Sectional Area of Conduit That May be Occupied by Cables
(1)	(2)	(3)
1	1·49 *d* (*see* Fig. 3 A)	45%
2	2·58 *d* (*see* Fig. 3 B)	30%
3	2·74 *d* (*see* Fig. 3 C)	40%
4	3·24 *d* (*see* Fig. 3 D)	38%
5	3·78 *d* (*see* Fig. 3 E)	For 5 or more cables 35%

NOTE — These capacities are valid only for conduit runs of length not exceeding 40 metres.



NOTE — Diagrams indicate group diameter of cables and minimum internal diameter of conduit in terms of cable diameter *d*.

FIG. 3 CONDUIT CAPACITIES

4.2.2 When all cables are not of the same size, the conduit diameter shall be worked out on percentage basis.

4.2.3 For diameters and thicknesses of conduits *see* IS : 1653-1972*.

4.3 Where a group of cables is to be run horizontally in a lift, they may be taped together at intervals and laid on the top of the next to last layer of concrete in the lift, covered with pads of fresh concrete throughout their length, and placement of the final concrete lift layer allowed to proceed in the normal manner. Leads of single or pairs of cables may be 'walked into' the concrete.

4.4 Cables of instruments located above terminal reading station are run in downward conduit from lift containing instrument with separate conduits serving each individual lift. Each cable shall be threaded individually into the conduit, so that each cable will be required to support only its own weight. At the entrance of the cables into the conduit, suitable protection, such as padding with burlap, should be provided around each cable and in the interstices between the cables to prevent sharp bends and to prevent the entrance of concrete and grout into the conduit.

4.5 Cable leads shall be run upward when the instruments are located below terminal reading station, without conduit from the lift in the case of concrete dam and within conduits in the case of masonry dam. Reinforcing bar shall be embedded in the concrete of successive lift for providing support for cables. The cables shall be tied to the reinforcing bars, at short intervals before placing each lift and the remainder of the cable coiled and hung clear of the fresh concrete.

4.6 In the general case where a number of cables from widely separated points are collected at one central point and run downward in conduit, the cable may be run in two steps. A collecting box or concrete form is erected around the grouped conduits, so that the lift is left about 450 mm below the conduits. During the placement of the concrete in which the meters are embedded, the cables should be brought horizontally to the collection point and then coiled and hung out of the fresh concrete. As soon as the concrete has set sufficiently to bear traffic, the cable coils shall be taken down the conduit to the terminal boards. The advantage is that it is much easier to sort and run cables when they are not muddled with fresh concrete.

4.7 If the cable leads are to cross contraction joints in the structure, a slack cable recess should be provided at the crossing point. This may consist of a wooden box block out, forming a recess into which the cable

*Specification for rigid steel conduits for electrical wiring (*second revision*).

will run. During placement of concrete in the adjacent block, a 300 mm loop of slack cable should be left in the unfilled block out and the remaining length of cable laid in the usual manner.

5. CABLE END PROTECTION

5.1 In order to prevent moisture and water from entering the instruments, the cable ends should be suitably sealed.

6. PRE-EMBEDMENT RESISTANCE MEASUREMENTS

6.1 Prior to embedment of instruments in the newly placed concrete, each instrument shall be thoroughly checked for meter resistance as also for lead resistance and these shall be entered in the *pro forma* given in Appendix A. The resistance ratios before splicing and after splicing shall also be recorded in the *pro forma* meant for recording pre-embedment tests. The pre-embedment tests quite often prove valuable during the analysis of data.

APPENDIX A

(*Clause* 6.1)

PRO FORMA FOR RECORD OF PRE-EMBEDMENT RESISTANCE MEASUREMENT

Resistance Type Pore Pressure Meters

Project	Instrument
Air temperature	Manufacturer's No.
Wet Bulb Temperature	Project No.
	Location

I. RESISTANCE BEFORE CABLE SPLICING

i) Red-black	ii) Red-green
iii) Green-black	iv) Resistance of one pair

II. RATIO INSTRUMENT ONLY

i) Direct ratio (white-green-black)

ii) Reverse ratio (black-green-white)

III. INDIVIDUAL CONDUCTOR RESISTANCE

i) Length
ii) Black
iii) Green-black
iv) Resistance one pair

IV. RATIO INSTRUMENT WITH CABLE

i) Direct ratio (red-black-green)
ii) Reverse ratio (green-black-red)

Date of Test:

Date of Embedment:

Name and Signature of
OBSERVER

Notes:

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2